

# MULTI-STAGE VACUUM PUMP

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a vacuum pump and, more particularly, to a multi-stage vacuum pump, which has a small outer diameter and reduced volume and weight and, which is inexpensive to manufacture.

### 2. Description of Related Art

Regular equipment for clean manufacturing process, for example, equipment for depositing process, etching process, ion implanting process in semiconductor manufacturing commonly use a vacuum system to provide a proper vacuum environment for operation.

In the aforesaid vacuum system, a vacuum pump is used to achieve the desired vacuum effect. Therefore, the quality of the vacuum pump determines the achievement of the vacuum system.

FIG. 1 is a sectional view of a multi-stage vacuum pump according to the prior art. According to this design, the multi-stage vacuum pump 9 is comprised of a plurality of casings 911~915 and a plurality of partition plates 921~924 axially alternatively arranged in a stack. FIG. 2 is an exploded view of one pump unit of the multi-stage vacuum pump 9. FIG. 3 is a sectional view of the assembly of FIG. 2. As illustrated, the pump unit comprises a casing 914, which defines a compression chamber 904 and an air path 900 extended around the compression chamber 904 and adapted to guide compressed air from the compression chamber 904 to a next

compression chamber 903 (see FIG. 1) for a next compression operation, a partition plate 924 covering the compression chamber 904, two shafts 931 and 932 arranged in parallel and extended through the partition plate 924, and two rotors 933 and 934 respectively formed integral with the shafts 931 and 932 and meshed together in the compression chamber 904 and adapted to compress air in the compression chamber 904.

As illustrated in FIGS. 2 and 3, the air path 900 is formed in the wall thickness of the casing 914 around the compression chamber 904. The presence of the air path 900 greatly increases the diameter and volume of the casing 914. Due to this drawback, the size and weight of the multi-stage vacuum pump 9 cannot be reduced to the desired level.

Therefore, it is desirable to provide a multi-stage vacuum pump, which eliminates the aforesaid drawbacks.

#### SUMMARY OF THE INVENTION

It is the main object of the present invention to provide a multi-stage vacuum pump, which has reduced outer diameter and volume. It is another object of the present invention to provide a multi-stage vacuum pump, which has a reduced weight to lower the manufacturing cost. According to one aspect of the present invention, the multi-stage vacuum pump is comprised of a plurality of casings, a plurality of partition plates, a mover module, and a synchronizer gear module. The casings are axially connected in series, each defining a compression chamber inside thereof. The partition plates each having a predetermined wall thickness, and each respectively mounted between two adjacent casings of the casings to separate the

compression chambers of the two adjacent casings. Each partition plate has two through holes. The mover module comprises two parallel shafts respectively extended through the two through holes of each of the partition plates, and a plurality of rotors symmetrically formed integral with the two parallel shafts respectively and arranged in pairs, wherein each pair of two adjacent rotors of the rotors received in one corresponding compression chamber of the casings for compressing air. The synchronizer gear module adapted to rotate the shafts and the rotors synchronously.

The main feature of the present invention is the design of the partition plates. Each partition plate has a front face, a rear face, and at least one air path respectively formed in the respective wall thickness and extended from the front face to the rear face. During operation, air is compressed by the corresponding rotors in the compression chamber in one casing, and the corresponding compression chamber forms a high-pressure zone. Compressed air immediately passes through the air path of the corresponding partition plate into the next compression chamber for further compression. When compressed air passed out of the compression chamber of one casing into the compression chamber of another casing, the antecedent compression chamber is changed from a high pressure status into a low pressure status. Thereafter, air in the next compression chamber is compressed by the corresponding rotors and forced to pass through the air path of the next partition plate to another next compression chamber. When repeatedly compressed in different compression chambers, finally compressed air flows out of the air outlet of the last casing. Because

compressed air directly passes through the air path in each partition plate unlike the conventional design of having compressed air to pass through the air path extending around the border area of each casing, the outer diameter and volume of the multi-stage vacuum pump can greatly be reduced to  
5 relatively lower the weight and manufacturing cost of the multi-stage vacuum pump.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a multi-stage vacuum pump according to the prior art.

10 FIG. 2 is an exploded view of one pump unit of the multi-stage vacuum pump according to the prior art.

FIG. 3 is a top view in section of the pump unit shown in FIG. 2.

FIG. 4 is a sectional view of a multi-stage vacuum pump according to the present invention.

15 FIG. 5 is an exploded view of one vacuum pump stage of the multi-stage vacuum pump according to the present invention.

FIG. 6 is a perspective assembly view of the partition plate shown in FIG. 5.

FIG. 7 is a schematic drawing showing an alternate form of the  
20 partition plate according to the present invention.

FIG. 8 is a schematic drawing showing another alternate form of the partition plate according to the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 4, a multi-stage vacuum pump 1 is shown

comprised of a plurality of casings 21~25, a plurality of partition plates 31~34, and a mover module 4. The casings 21~25 are axially connected in series, each defining a respective compression chamber 211~251 inside thereof. The partition plates 31~34 each having a predetermined wall thickness  $t$ , and each respectively mounted between two adjacent casings 21~25 to separate the compression chambers 211~251 from one another.

Referring to FIGS. 5 and 6 and FIG. 4 again, the partition plates 31~34 are identical. FIGS. 5 and 6 show only one partition plate 34 for explanation. The partition plate 34 has two through holes 301 and 302. The aforesaid mover module 4 comprises two parallel shafts 41 and 42 suspended in the compression chambers 211~251 and respectively extended through the two through holes 301 and 302 of every partition plate 31~34, a plurality of rotors 411 and 421 respectively symmetrically formed integral with the two parallel shafts 41 and 42 respectively and arranged in pair, and each pair of the two adjacent rotors 411 and 421 received in one of the compression chambers 211~251 inside the casings 21~25, a synchronizer gear module 5 adapted to rotate the shafts 41 and 42 and the rotors 411 and 421 synchronously without causing a contact between each two adjacent rotors 411 and 421.

The partition plate 34 has a front face 342, a rear face 343, an air path 341 in the wall thickness  $t$ , a front opening 351 in the front face 342, and a rear opening 352 in the rear face 343. The rear opening 352 is in air-communication with the front opening 351 through the air path 341. According to this embodiment, the partition plate 34 is formed of a left

partition plate member **344** and a right partition plate member **345**. The left partition plate member **344** and the right partition plate member **345** are abutted against each other. The left partition plate member **344** defines therein a left air path **346**. The right partition plate member **345** defines therein a right air path **347**. The left air path **346** and the right air path **347** form the aforesaid air path **341**. The air path **341** is formed in the partition plate **34** between the two through holes **301** and **302**.

During operation, air passes through an air inlet **252** in the casing **25** into the corresponding compression chamber **251**, and then compressed by the corresponding rotors **411** and **421** at the shafts **41** and **42**. At this time, the compression chamber **251** forms a relatively high-pressure zone, and compressed air passes through the front opening **351** of the corresponding partition plate **34** into the air path **341** and then into the next compression chamber **241** via the rear opening **352**. When compressed air passed out of the compression chamber **251** into the next compression chamber **241**, the compression chamber **251** is changed from a high pressure status into a low pressure status. Thereafter, air in the next compression chamber **241** is compressed by the corresponding rotors **411** and **421** at the shafts **41** and **42**, and forced to pass through the air path **331** of the next partition plate **33** to another next compression chamber **231**. When repeatedly compressed in different compression chambers **211~251**, finally compressed air flows out of the air outlet **212** of the casing **21**.

As indicated above, when compressed in one compression chamber **221~251**, compressed air directly passes through the air path **311~341** of the

corresponding partition plate 31~34 to the next compression chamber 211~241. In comparison to the conventional air path design of extending around the border of each compression chamber, the casings 21~25 can be made relatively smaller than the conventional design without changing the capacity, i.e., the outer diameter and volume of the multi-stage vacuum pump 1 can effectively be reduced to lower the weight and the manufacturing cost.

Referring to FIGS. 4 and 5 again, the partition plate 34 has an annular groove 348, and an elastomer 64 mounted in the annular groove 348 (the other partition plates 31~33 have mounted therein a respective elastomer 61~63). After installation of the partition plate 34 in the corresponding case 25, the elastomer 64 seals the compression chamber 251, and absorbs the gap between the wall thickness  $t$  of the partition plate 34 and the corresponding mounting groove 253 at the casing 25, preventing occurrence of vibration noises.

FIG. 7 shows an alternate form of the partition plate. According to this alternate form, the partition plate, referenced by 7, is comprised of three partition plate members 71~73 abutted against one another, and the air path 74 is formed surrounding the through holes 701 and 702 in the partition plate 7.

FIG. 8 shows another alternate form of the partition plate. According to this alternate form, the partition plate, referenced by 8, is comprised of four partition plate members 81~84 abutted against one another, and the air path 85 is formed surrounding the through holes 801

and 802 in the partition plate 8. The air path 85 can be made having a different size. Therefore, the partition plate according to the present invention is not limited to the composition of two partition plate members, i.e., the partition plate can be formed of multiple partition plate members abutted against one another. Further, the size of the air path can be properly changed.

Although the present invention has been explained in relation to its preferred embodiments, it is to be understood that many other possible modifications and variations can be made without departing from the spirit and scope of the invention as hereinafter claimed.